Attorney Docket No. 24294.00

IN THE APPLICATION

OF

PETER D. GONZALES

FOR A

<u>PIPE INLET/OUTLET FLOW ENHANCEMENT DEVICE</u>

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PIPE INLET/OUTLET FLOW ENHANCEMENT DEVICE

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to fluid handling, and in particular to a device inserted into the inlet or outlet of a pipe for increasing the flow rate of fluids, particularly substantially incompressible fluids, between a container and a pipe. The pipe inlet/outlet device has particular utility in storm drainage pipe systems having a pipe inlet in a manhole, catch basin, or other tank and provides an efficient, simple, low cost means to enhance the flow capacity of a pipe.

2. DESCRIPTION OF THE RELATED ART

In many fluid handling situations, a fluid, such as an incompressible liquid, may be stored or temporarily retained in a tank and then drawn from the tank through a pipe. Engineers will sometimes determine the diameter of the pipe based on the needed flow requirements, while neglecting the importance of the entry (or exit) configuration. For example, a pipe extending directly and abruptly from the inner tank wall will cause fluid entering the pipe to have a significant radial vector component. The fluid's momentum entering the pipe at the edges will cause it to

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resist turning the corner and traveling parallel with the axis of the pipe. This sets up an annular region of low pressure just inside the pipe opening which generates annular vortices, effectively restricting the size of the inlet to the pipe. Other inlet configurations can also reduce the fluid flow. Likewise, fluid exiting an abrupt pipe outlet will experience pressure loss resulting from shear and other forces.

This has been especially problematic in the area of storm water drainage. In a typical storm water control application, civil engineers will determine how much storm water runoff is generated from a subject area for a particular "design storm event" and compare the storm runoff rate with the capacity of the pipe. If the calculated capacity of the pipe exceeds the generated runoff rate then the pipe is deemed to have sufficient size. However, many engineers do not consider or have control over the entry configuration of the installed pipe. The resultant reduction of flow entering the pipe can cause system overflow or "failure." The result of this system failure could be severe erosion, flooding, or other unintended costly damage.

When a designer does consider the entry configuration, he or she must assume the worst case scenario due to inconsistency in pipe end configurations installed by the contractor. The

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result is an over-designed system that requires an inflated cost.

The inventor is not aware of any related art that addresses this existing problem. United States Des. Patent No. 243,766, issued March 22, 1977 to Isaacs, shows an ornamental design for a sump basin having funnel-shaped side connections for attaching a pipe thereto. In addition, U.S. Patent 5,772,694, issued June 30, 1998 to Bokros et al., addresses this problem as it relates to artificial heart valves by integrally forming a flared inlet having a toroidal curvature into the valve body (see, e.g., col. 8, lines 23-52). Since it is integrally formed with the valve body, this solution could not be adapted for most pipe inlets, since most pipes are formed by extrusion processes or other processes that result in a constant diameter pipe. Secondly, it cannot cure existing abrupt-inlet pipes.

It is also known to provide tapering inlets to concrete drainage culverts to improve drainage efficiency. See, for example, section 4, "Improved Inlets" of the document entitled, "Hydraulic Design Manual" available on a web page published by the Texas Department of Transportation at least as of February 26, 2004. These tapered or flared inlets are formed integrally with the throat and face sections at either end of the tapered portion. Therefore, this solution is also unsuitable for catch

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basins and other fluid handling systems having a pipe extending from a tank for the reasons mentioned above. In addition, the tapered culvert inlet concept is not a retrofit solution to increase the capacity of existing fluid handling systems.

However, such designs are difficult to implement within the confines of a catch basin or manhole. Because of the abrupt transition at the pipe entry in such systems, the full capacity of a theoretical open channel pipe system is rarely realized. Typically, water will back up in the catch basin or manhole. The backup of water results in an increase in the head or pressure of the outgoing water and results in water being "pushed" into the outflow pipe. It also begins to affect the outflow characteristics of the incoming pipe flows. The traditional solution has been to either increase the depth of the pipe system or the diameter of the pipe, or both.

Various experiments and academic studies have shown that there is a smaller loss in the pressure head when a pipe inlet is rounded than when the pipe inlet is square-edged. *The Handbook of Mechanical Engineering*, published by the Research & Education Association, Piscataway, New Jersey (1999) at page C-82, and Nakayama et al., *Introduction to Fluid Mechanics*, published by John Wiley & Sons, Inc., New York (1999) at page 121 show formulae and tables reflecting a smaller friction

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coefficient for pressure head loss in pipe inlets having rounded corners. Nevertheless, many existing storm drainage installations have a square-edged pipe inlet, and many new storm drainage installations continue to utilize a square-edged or abrupt pipe inlet. Such installations provide an acceptable level of service for some period of time. However, it is often desired to improve the environs of the storm drainage area, placing an additional burden upon the storm drainage system that it was not designed to handle.

In such circumstances, the builder is faced with the option of replacing the pipe with a larger diameter pipe, lowering the pipe system to a greater depth, or re-designing the pipe inlet. There are no fittings currently available to retrofit an existing storm drainage pipe inlet to reduce head loss to the inventor's knowledge. Consequently, the latter option requires custom designing a new pipe inlet. Where the pipe inlet is located in an open area, e.g., an embankment of the like, this can be done, but it requires considerable time, expense, and is not always entirely satisfactory. Where the pipe inlet is in a restricted area, e.g., a manhole or catch basin, custom re-design of the pipe inlet is even more difficult or impossible to achieve, and the custom design is often not portable to other manholes or catch basins.

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Consequently, there is a need for a pipe fitting that can be installed at the inflow end of a pipe or conduit in a storm drainage pipe system that reduces head loss at the pipe inlet. Such a fitting is particularly desired for pipe inlets located in restricted surroundings.

It has therefore not heretofore been recognized that there exists a need to provide a simple inexpensive device for providing a rounded inlet into existing or newly-installed pipes, particularly from retention tanks, and more particularly in the field of storm drainage. Such a device may permit smaller pipe diameters for a given flow, shallower pipe designs for gravity fed systems, increased capacity of existing systems, enhanced debris passing capacity, and better consistency in pipe entry configurations.

None of the above inventions and patents, taken either singly or in combination, is seen to describe the instant invention. Thus, a pipe inlet/outlet device solving the aforementioned problems is desired.

SUMMARY OF THE INVENTION

The pipe inlet/outlet device of the present invention is a molded fitting that is attached to the inflow end of a pipe conduit. The pipe inlet/outlet device has a neck portion and a

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rounded or smoothly curving mouth extending from the neck portion. The neck portion is a hollow cylinder that is open at both ends. The neck portion has an outside diameter sized to fit snugly in the open end of a pipe. The rounded mouth is integral with and extends from the neck portion, gradually curving outward and away from the neck and terminating at a lip, forming a skirt disposed around the inlet that may be filled with grout. The pipe may be an outlet from a tank, such as a manhole or catch basin. The pipe inlet/outlet device is inserted into the open end of the pipe for reducing head losses at the open end.

The pipe inlet/outlet device may be made from any hard, durable substance, and may be attached to the inflow end of a pipe or conduit by mechanical, adhesive, or other forming means. Use of the pipe inlet/outlet device reduces head losses at the inflow end of the pipe, allowing the pipe system to reach or closely approach full capacity, thereby reducing pipe diameter requirements and permitting storm drainage pipe system installation at shallower depths.

These and other features of the present invention will become readily apparent upon further review of the following specification and drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a cross-sectional view of a tank having a pipe extending therefrom and a pipe inlet/outlet device according to the present invention installed at the inflow end of the pipe.

Fig. 2 is an enlarged section view showing further details of the pipe inlet/outlet device according to the present invention.

Fig. 3 is a front view of the pipe inlet/outlet device according to the present invention.

Fig. 4 is a side view of the pipe inlet/outlet device according to the present invention.

Figs. 5A, 5B, and 5C are cross section views showing alternative embodiments of the pipe inlet/outlet device according to the present invention.

Figs. 6A, 6B, and 6C are partial cross sections showing alternative surface texturing of the pipe inlet/outlet device according to the present invention.

Fig. 7A is a cross section view of an alternative embodiment of the pipe inlet/outlet device according to the present invention having ribs extending into the fluid flow.

Fig. 7B is a cross section view of an alternative embodiment of the pipe inlet/outlet device according to the present invention having grooves formed into the device body.

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Fig. 7C is a cross section view of an alternative embodiment of the pipe inlet/outlet device according to the present invention of the pipe inlet/outlet device according to the present invention having spiral flow inducing ribs extending into the fluid flow.

Fig. 7D is a cross section view of an alternative embodiment of the pipe inlet/outlet device according to the present invention having spiral flow inducing grooves formed into the device body.

Similar reference characters denote corresponding features consistently throughout the attached drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 shows an exemplary tank 10 having a pipe 30 extending therefrom. Tank 10 retains a fluid 12 having a surface 14. Pipe inlet/outlet device 50 provides smooth, laminar flow into pipe 30 as shown by arrows 20 from tank 12, thereby preventing annular vortices just inside inlet of pipe 30, and consequential pressure loss.

Referring now to Figs. 2-4, device 50 includes a neck 52 that is force fit into opening 32 of pipe 30. Device 50 may be retained in pipe 30 by a friction fit, adhesive, or some combination thereof. Other means for retaining device 50 as

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would occur to the ordinary practitioner are contemplated as well. Since pipes are generally produced with a defined inside diameter and varying thickness (and therefore varying outside diameters), device 50 is preferably produced having an outside diameter sized to fit snugly in a pipe opening.

Device 50 extends up from neck 52 to lip 51, thereby defining a fluid passage having a rounded, gradually curving mouth 54. The mouth 54 extends outward to a rounded leading edge of rim 56 and then curves rearward to define a skirt 58 terminating at lip 51. Skirt 58 defines a recess which can be filled with grout, adhesive, or other filler material (not shown) to fill the gap between lip 51 and the wall of tank 10, preventing seepage of water between the wall of the tank 10 and pipe 30. It may be determined that, e.g., for the purposes of enhancing the pipe inlet/outlet device's longevity, such an extension of lip 51 to the tank wall by grout or other filler may be desirable. Although pipe inlet/outlet device 50 is shown projecting into the tank 10 in Fig. 1, it will be understood that, depending upon the construction of the tank walls, it may be possible to install the device 50 on the end of the pipe 30 in a recess formed in the wall of the tank 10, the outer portion of the rim 56 being packed with grout or other filler so that

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the leading edge of the rim 56 is flush with the wall of the tank 10 to further minimize head loss.

Device 50 is preferably made from a plastic, such as recycled high-density polyethylene, although other polymers, resins, and composites are contemplated, e.g., polypropylene, polyvinyl chloride, etc. Plastics have the advantage of being lightweight, economical, and reasonably corrosion resistant. Depending on the application, metal devices may be desired, though it is important that relative thermal expansion rates be considered when fitting them to plastic pipes. An advantage of metal devices is that, metal being a stronger material, the neck portion may be made thinner, thereby making more of the cross-section flow area available at the neck.

Mouth 54 is preferably circular, being symmetrical about longitudinal axis 38. Further experimentation will determine an optimum cross section radius of curvature of rim 56. Nevertheless, a radius of curvature of about one quarter the diameter of pipe 30 may be effective at reducing inlet pressure losses for typical storm drainage catch-basin applications. Depending on the application, larger size devices may be appropriate. For example, a higher pressure gradient through opening 32 will result in higher velocity flow, which therefore requires a larger turning radius to prevent separation, the

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generation of annular vortices, and consequential flow restriction.

Other shapes are contemplated and experimentation will determine optimal cross-sectional shapes. Exemplary shapes are shown in Figs. 5A, 5B,and 5C, which show cross sections of alternative pipe inlet/outlet device embodiments. The embodiment shown in Fig. 5A has an elliptical cross section shape on either side of axis 38. The elliptical shape means that fluid velocity increases at a more gradual rate as it approaches opening 32 than it would for the embodiment shown in Figs. 1-4.

The embodiment shown in Fig. 5B has a fluid pathway that resembles a trumpet bell. This shape has steadier fluid acceleration and a more rounded rim 56 than previous embodiments, but is larger and requires more material.

The embodiment shown in Fig. 5C has a spiral cross section on either side of axis 38. This shape provides a radius of curvature that steadily decreases the further it is from opening 32. In this manner the cross section shape is spiral. The advantage is that the faster the fluid, the more rounded the turn it has to make, thereby reducing the chance of separation.

In addition, it has been discovered, for example, with respect to such fluid dynamics problems as golf balls and

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America's Cup yacht racing, that small turbulence-inducing structures (hereinafter "turbulators") formed into the flow-contacting surface generate a turbulent boundary layer that can actually reduce drag, and therefore pressure loss. Fig. 6A, shows a first embodiment of turbulators in the form of dimples 62. Fig. 6B shows a second embodiment of turbulators in the form of raised nubs 64. Fig. 6C shows a third embodiment of turbulators in the form of microgrooves 66 (all exaggerated for purposes of clarity). Further experimentation will determine if turbulators can significantly increase flow rate by reducing pressure loss at inlet 32.

Fig. 7A shows a plurality of axially-aligned ribs 72 extending into the flow path for organizing the flow and preventing a swirling effect. Fig. 7B shows a plurality of grooves 74 for the same purpose. Axially-aligned ribs 72 and grooves 74 are formed normal to a plane perpendicular to axis 38. Experimentation will determine if ribs 72 and/or grooves 74 may improve flow characteristics, thereby improving the performance of device 50.

Fig. 7C shows a plurality of spiral ribs 76 extending into the flow path to generate a swirling or axial vortex. Fig. 7D shows a plurality of spiral grooves 78 for the same purpose. Spiral ribs 76 and spiral grooves 78 form an acute angle with a

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plane perpendicular to axis 38. As before, further experimentation will determine if spiral ribs 76 and/or spiral grooves 78 may enhance the flow characteristics and improve the performance of device 50.

It is to be understood that the present invention is not limited to the embodiments described above, but encompasses any and all embodiments within the scope of the following claims. For example, it is within the scope of the invention that the device be placed over the outlet end of a pipe as well as the inlet end.

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